PA 1170850

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

May 19, 2004

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: *60/462,580*
FILING DATE: *April 11, 2003*

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS
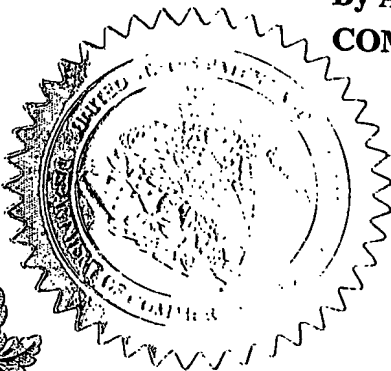
P. SWAIN
Certifying Officer

PROVISIONAL APPLICATION FOR PATENT
COVER SHEET

Case No. HAHN22.001PRF
Date: April 11, 2003
Page 1

United States Patent and Trademark Office
P.O. Box 2327
Arlington, VA 22202

ATTENTION: PROVISIONAL PATENT APPLICATION

Sir:

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR § 1.53(c).

For: **LOW SULPHER DIESEL FUEL AND AVIATION TURBINE FUEL**

Name of First Inventor:	Delanie LAMPRECHT
Residence Address:	Greenacres
	2 Wenning Street
	SW 5 - Vanderbijlpark
	1911
	SOUTH AFRICA

Name of Second Inventor:	Petrus Nicolaas Johannes ROETS
Residence Address:	5 Rennert Street
	SW 2 - Vanderbijlpark
	1911
	SOUTH AFRICA

Enclosed are:

(X)   Specification in 24 pages.

(X)   11 figures.

(X)   A check in the amount of $160 to cover the filing fee is enclosed.

(X)   A return prepaid postcard.

(X)   The Commissioner is hereby authorized to charge any additional fees which may be required, now or in the future, or credit any overpayment to Account No. 11-1410.

Was this invention made by an agency of the United States Government or under a contract with an agency of the United States Government?

(X)   No.

( )   Yes. The name of the U.S. Government agency and the Government contract number are:

PROVISIONAL APPLICATION FOR PATENT
COVER SHEET
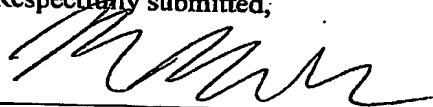
Case No. HAHN22.001PRF
Date: April 11, 2003
Page 2

(X)   Please send correspondence to:

Rose M. Thiessen
Knobbe, Martens, Olson & Bear, LLP
2040 Main Street, 14th Floor
Irvine, CA 92614

Respectfully submitted,

Rose M. Thiessen
Registration No. 40,202
Customer No. 20,995.
(619) 235-8550

S:\DOCS\RMT\RMT-9297.DOC
041103

Knobbe Martens Olson & Bear LLP
Intellectual Property Law

04-15-03

2040 Main Street
Fourteenth Floor
Irvine, CA 92614
Tel 949-760-0404
Fax 949-760-9502
www.kmob.com

Rose M. Thiessen, Ph.D.

BOX PROVISIONAL PATENT APPLICATION
United States Patent and Trademark Office
P.O. Box 2327
Arlington, VA 22202

CERTIFICATE OF MAILING BY "EXPRESS MAIL"

Attorney Docket No.	:	HAHN22.001PRF
Applicant(s)	:	Lamprecht, et al.
For	:	LOW SULPHER DIESEL FUEL AND AVIATION TURBINE FUEL
Attorney	:	Rose M. Thiessen
"Express Mail" Mailing Label No.	:	EV 2301 768 10 US
Date of Deposit	:	April 11, 2003

I hereby certify that the accompanying

Transmittal letter; specification in 25 pages; 11 Figures which are included in the specification; Check(s) for Filing Fee(s); Return Prepaid Postcard

are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and are addressed to the United States Patent and Trademark Office, P.O. Box 2327, Arlington, VA 22202.

Craig Smelter

S:\DOCS\RMT\RMT-9298.DOC
041103

San Diego	San Francisco	Los Angeles	Riverside	San Luis Obispo
619-235-8550	415-954-4114	310-551-3450	909-781-9231	805-547-5580

LOW SULPHUR DIESEL FUEL AND AVIATION TURBINE FUEL

Field of the Invention

The invention relates to a low sulphur diesel fuel and to an aviation fuel and a blending stock for aviation fuel.

Background to the Invention

In this specification reference is made to Low Temperature Fischer-Tropsch (LTFT) fuel. This LTFT process is a well known process in which carbon monoxide and hydrogen are reacted over an iron, cobalt, nickel or ruthenium containing catalyst to produce a mixture of straight and branched chain hydrocarbons ranging from methane to waxes and smaller amounts of oxygenates. This hydrocarbon synthesis process is based on the Fischer-Tropsch reaction:

$2\ H_2\ +\ CO\ \rightarrow\ \sim[\ CH_2\ ]\sim\ +\ H_2O$ where $\sim[\ CH_2\ ]\sim$ is the basic building block of the hydrocarbon product molecules.

The LTFT process is used industrially to convert synthesis gas, which may be derived from coal, natural gas, biomass or heavy oil streams, into hydrocarbons ranging from methane to species with molecular masses above 1400. While the term Gas-to-Liquid (GTL) process refers to schemes based on natural gas, i.e. methane, to obtain the synthesis gas, the quality of the synthetic products is essentially the same once the synthesis conditions and the product work-up are defined.

While the main products are linear paraffinic materials, other species such as branched paraffins, olefins and oxygenated components may form part of the product slate. The exact product slate depends on reactor configuration, operating conditions and the catalyst that is employed, as is evident from articles such as Catal.Rev.-Sci. Eng., 23 (1&2), 265-278 (1981) or Hydroc. Proc. 8, 121-124 (1982).

Preferred reactors for the production of heavier hydrocarbons are slurry bed or tubular fixed bed reactors, while operating conditions are preferably in the range of 160–280°C, in some cases in the 210-260°C range, and 18–50 bar, in some cases preferably between 20-30 bar.

The catalyst may comprise active metals such as iron, cobalt, nickel or ruthenium. While each catalyst will give its own unique product slate, in all cases the product slate contains some waxy, highly paraffinic material which needs to be further upgraded into usable products. The LTFT products can be hydroconverted into a range of final products, such as middle distillates, naphtha, solvents, lube oil bases, etc. Such hydroconversion, which usually consists of a range of processes such as hydrocracking, hydrotreatment and distillation, can be termed a LTFT Products Work-up process. Typically the process is normally configured in such a way that only two liquid products are transferred to storage. In most instances a small amount of light hydrocarbons containing up to four carbon atoms is also co-produced. The typical quality of the LTFT liquid products is presented in Table 1.

2

Table 1   Typical Quality of the LTFT Products

	LTFT Naphtha	LTFT Diesel
Density, kg/L (20°C)	0,685	0.765
Distillation		
▪ IBP, °C	54	151
▪ T10, °C	81	182
▪ T50, °C	101	249
▪ T90, °C	120	317
▪ FBP, °C	131	334
Composition, % wt		
▪ n-paraffins	59,0	31,9
▪ iso-paraffins	38,2	67,1
▪ Naphthenics	ND	ND
▪ Aromatics	0,3	ND
▪ Olefins	2,5	ND
▪ Oxygenates	ND	ND
Iso:Normal Paraffin ratio	0,65	2,10

The applicant has identified a need to utilise LTFT fuel, including GTL fuel, directly, without blending with cracked stocks, as a fuel that will be interchangeable with conventional diesel fuels.

Semi-synthetic aviation fuel was approved in 1999 under British Aviation Turbine Fuel Defence Standard 91-91 (DEF STAN 91-91) specifications.

A need has thus been identified for a synthetic based fuel which meets or exceeds the above standards and which permits use of LTFT products, including GTL products, or components thereof in the aviation industry as fuels and/or as blend stocks for fuels.

Summary of the Invention

3

According to a first aspect of the invention there is provided a process for the production of a synthetic low sulphur diesel fuel and an aviation fuel from a Low Temperature Fischer-Tropsch (LTFT) feedstock, said process including the fractionation of the Low Temperature Fischer-Tropsch feedstock into a light kerosene fraction useable as an aviation fuel and/or an aviation fuel blend stock, and a heavier diesel fraction useable as a synthetic low sulphur diesel fuel and/or a diesel fuel blend stock, said fractions substantially complying with diesel and aviation fuel specifications.

Surprisingly, the diesel fuel meets the lubricity specification without the use of additives, although being highly hydrogenated. Usually those skilled in the art would expect highly hydrogenated fuel to need lubricity improvers.

This has been identified as one method to improve the density as well as energy density of LTFT Fuel and also adhering to the cold flow properties (CFPP – cold filter plug point test) and lubricity specifications while producing a lighter kerosene fraction that is useable either to blend with crude oil derived blending stock to produce a semi-synthetic aviation fuel or directly as a synthetic aviation fuel.

The process includes the fractionation and removal of at least 33 volume% of the LTFT feedstock to form said aviation fuel or blending stock having a final boiling point of about 270°C.

Typically, the process includes fractionation and removal of 45 volume%, or even 55 volume% of the feedstock.

The light kerosene fraction may be cut to meet the – 47°C freezing point of Jet A-1 at a cut point of 270°C. Again the lubricity properties measured with the ball on cylinder lubricity evaluator (BOCLE) of the kerosene fraction was above expectations.

According to a second aspect of the invention, there is provided a synthetic low sulphur fuel or blend stock for a low sulphur fuel, said fuel or blend stock having the following properties:
-       iso:n-paraffins mass ratio of from 2 to 5
-       less than 0.001%m/m aromatics;

4

- CFPP according to IP309 of below -5°C; and
- density@20°C of at least 0.780 kg/l.

Typically the iso:n paraffins mass ratio is from 3 to 4.

The iso:n paraffins mass ratio may be 3.7.

Typically the CFPP is below -9°C.

Surprisingly, the fuel meets the lubricity specification without the use of additives, although being highly hydrogenated.

Advantageously, the emission performance was not adversely affected when compared to a crude derived low sulphur fuel.
The fuel or blend stock may be a LTFT diesel fraction.

The blend stock may have viscosity@40°C of above 2cSt.

The fuel or blend stock may have a final boiling point of above 330°C, typically about 340°C.

The fuel or blend stock may have an IBP of above 200°C, typically above 250°C, in some embodiments in excess of 265°C.

According to a third aspect of the invention, there is provided a synthetic aviation fuel blend stock for a semi-synthetic aviation fuel, said blend stock having the following properties:
- iso:n-paraffins mass ratio of 0.5 to 3
- less than 0.1%m/m aromatics;
- freezing point of below -47°C; and
- density@20°C greater than 0.75 kg/l.

Typically the iso:n paraffins mass ratio is from 1 to 2.

5

The iso:n paraffins mass ratio may be 1.2, or 1.16.

The blend stock may be used directly as a fully synthetic aviation fuel without blending with crude derived fuel components.

The blending stock may have a lubricity (BOCLE) in excess of 0.5.

The blending stock may be a LTFT kerosene fraction.

The blend stock may have viscosity@-20°C less than 8cSt, typically 4cSt.

The blend stock may have a final boiling point of above 200°C, typically about 270°C.

According to a fourth aspect of the invention, there is provided a semi-synthetic aviation fuel having the following properties:
-      iso:n-paraffins ratio of 0.5 to 3;
-      at least 8%m/m aromatics;
-      freezing point of below -47°C; and
-      density@15°C of at least 0.775 kg/l.

Typically the iso:n paraffins mass ratio is from 1 to 2.

The iso:n paraffins mass ratio may be 1.8.

The blend stock may have viscosity@-20°C of below 8cSt, or even below 4 cSt.

With a 50 vol-% blend of LTFT kerosene and Natref Kero-Merox™, the minimum density and aromatic content requirements according to the American Society for Testing and Material (ASTM D1655) and the British Aviation Turbine Fuel Defence Standard 91-91 for Jet A1 were met.

Since LTFT fuel is composed almost only of normal and isoparaffins, a LTFT kerosene fraction may be utilised as a aviation turbine fuel blending component. The virtual absence of aromatics and naphthenes from LTFT kerosene may provide it with a very

good smoke point number (i.e. it produces very little soot).

According to a fifth aspect of the invention there is provided a thermally stable aviation fuel with low deposition tendency, said fuel including one or more of a fully synthetic aviation fuel, a semi synthetic aviation fuel, and a synthetic aviation fuel blend stock, as described above.

Typically the aviation fuel and blend stock has a thermal stability tube deposit rating at 260°C less than 1.

Typically the aviation fuel has a Quartz Crystal Microbalance (QCM) deposition less than 3 $\mu g/cm^2$.

More typically, the aviation fuel has QCM deposition of less than 2 $\mu g/cm^2$ for a 15h QCM test @ 140°C without addition of an anti-oxidant.

According to a sixth aspect of the invention there is provided a low soot emission aviation fuel, said fuel including one or more of a fully synthetic aviation fuel, a semi-synthetic aviation fuel, and a synthetic aviation fuel blend stock, as described above.

Typically the aviation fuel blend stock has about a 33% reduction in the normalized particulate number density under cruise conditions, more typically a 60% reduction under cruise conditions and a 67% reduction in the normalized particulate number density under idle conditions, more typically a 83% reduction under idle conditions compared to typical JP 8 jet fuel.

Description of Embodiments of the Invention

The invention will now be described with reference to specific embodiments which illustrate the invention but are not intended to limit its application.

7

Examples

Low Sulphur Diesel Fuel

GTL Fuel was fractionated targeting a 55 vol-% GTL kerosene cut with a final boiling point of 280°C. The freezing point requirement for Jet A1 was not met and the cut point was further reduced to 270°C (45 vol-%). The resultant diesel fuel properties and kerosene properties are shown in Table 1 and include density, viscosity, high-frequency reciprocating rig (HFRR) and ball-on-cylinder evaluator (BOCLE) lubricity test and cold filter plugging point (CFPP) of diesel and freezing point of kerosene.

8

Table 1: Selected fuel properties of GTL Fuel, the heavier diesel fraction and the lighter kerosene cut obtained through fractionation.

			GTL Diesel	GTL Diesel 1	GTL Jet Fuel 1	GTL Diesel 2	GTL Jet Fuel 2
Product Yield		vol %	100%	45%	55%	55%	45%
Density @ 15°C	ASTM D4052	kg/l	0.769	0.790	0.752	0.786	0.747
Density @ 20°C	ASTM D4052	kg/l	0.765	0.786	0.748	0.782	0.743
H2 content	ASTM D5291	mass %	14.97	14.62	15.00	14.68	14.87
Distillation	IBP	°C	151	268	157	246	154
ASTM D86	10%	°C	182	282	172	262	168
	50%	°C	249	300	203	289	191
	95%	°C	325	336	267	333	254
	FBP	°C	334	341	278	339	267
Flash point	ASTM D93	°C	58	114	50	122	45
Freezing point	ASTM 5901	°C	-15		-42		-48
CFPP	IP 309	°C	-19	-9		-12	
Viscosity @ -20°C	ASTM D445	cSt			4.26		
Viscosity @ 40 °C	ASTM D445	cSt	1.97	3.90		3.31	
Lubricity (HFRR)	ASTM D6079	µm	617	450		446	
Lubricity (BOCLE)	ASTM D5001	mm			0.52		0.50
Cetane number	ASTM D613		72			74.7	
Density @ 20°C	ASTM D4052	(kg/l)	0.765	0.786	0.748	0.782	0.743
Heating Value	GHV	MJ/kg	46.96	46.55	47.13	46.97	47.24
ASTM D240	NHV	MJ/kg	43.79	43.44	43.95	43.86	44.09
	NHV	MJ/l	33.50	34.13	32.88	34.25	32.75

In the

In table 1:

GTL Diesel is is the full distillation range LTFT diesel

GTL Diesel 1 is a 45% heavy end LTFT diesel

GTL Diesel 2 is a 55% heavy end LTFT diesel

GTL Jet Fuel 1 is a 45% light end LTFT kerosene cut

GTL Jet Fuel 2 is a 55% light end LTFT kerosene cut

GTL Jet Fuel 2 is

Table 2: Selected fuel properties of the GTL kerosene fractions and a blend thereof with crude derived Kero Merox.

Analysis	Units	Kero Merox	50/50 blend	DEF STAN 91-91	
				min	max
Total Aromatics	vol%	19.8	9.9	8	25
Density					
@ 15°C	kg/l	0.809*	0.776*	0.775	0.840
@ 20°C	kg/l	0.805	0.772	0.771*	0.836*
Distillation D86					
IBP	°C	158	152		
10%	°C	176	169		205
50%	°C	206	194		
95%	°C	259	253		
FBP	°C	267	267		300
Flash point	°C	55		38	
Viscosity @ -20°C	cSt	4.51	3.65		8
Freezing point	°C	-48	-51		-47
Lubricity (BOCLE)	mm	0.48	0.51		0.85

* Calculated

Diesel fractions

The 45 vol-% heavy end diesel fraction has excellent properties for use as a neat GTL diesel without the use of additives

10

Swedish EC1 low sulphur and aromatic diesel has a net volumetric heating value (energy density) of 35.3MJ/l. The net volumetric heating value of the 45 vol-% diesel fraction is 34.1MJ/l (see Table 1).
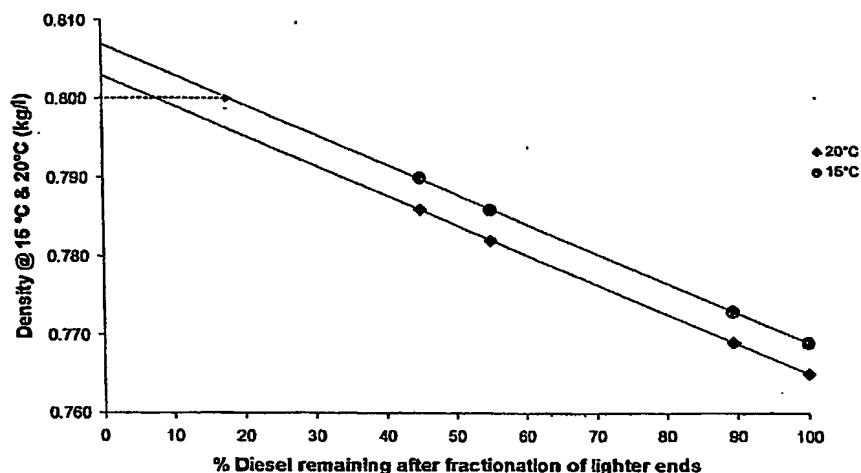

Figure 1:   Graph of GTL diesel densities at various degrees of fractionation

A maximum wear scar diameter (WSD) of 460 μm is allowed according to the EN 590:1999 Diesel Fuel Specifications. The lubricity of the GTL diesel fractions improved considerably and meets the current specification requirement because of the higher viscosity of the diesel fractions, which improve the hydrodynamic lubrication.

The flash points of the GTL diesel fractions are high because of its higher initial boiling point whereas the cold flow properties of the diesel fraction remained good.

11

According to Gas Chromatograph Mass Spectrometry (GC MS) and Gas Chromatograph Flame Ionisation Detection (GC-FID) results GTL Fuel prior to fractionation to kerosene and a diesel, has an isoparaffin to normal paraffin ratio of 2.2:1. The 55% heavy end diesel cut has a isoparaffin to normal paraffin ratio of 3.71.
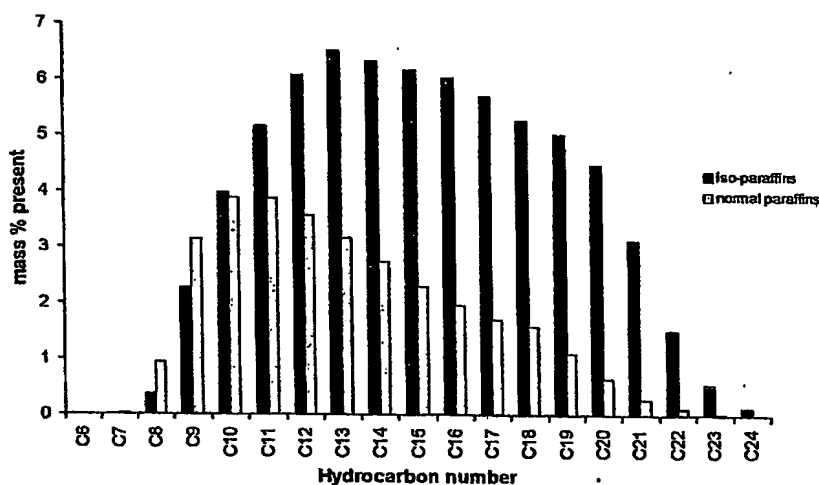

Figure 2: Carbon distribution of GTL Fuel

Fractionation of GTL Fuel results in a diesel having a much higher density and energy density which results in better fuel economy or more power. It also revealed other changes after fractionation including a huge improvement in its lubricity, a much higher viscosity and flash point. The good cold flow properties did not decreased dramatically although the diesel fraction is much heavier.

Aviation Fuel

The above tables and discussion regarding the low sulphur diesel fuel refer.

Kerosene fractions – Fully synthetic Aviation Fuel or Blending Stock

Viscosity and freezing point are the physical properties used to quantitatively characterise jet fuel fluidity and only an upper viscosity limit is therefore specified for jet fuel to which the fully synthetic GTL kerosene fractions conform. The light 45 vol-% GTL fully synthetic kerosene fraction met the required freezing point of –47°C for Jet A1 according to the DEF STAN 91-91 with a freezing point of –48°C (see Table 1). The low

freezing point, determined in accordance with the automated ASTM 5901 test method, is believed to be attributable to the more than 60 mass-% iso-paraffins present in GTL Fuel and more than 50 mass-% iso-paraffin present in the fully synthetic GTL kerosene cut.

The amount of energy contained in a given quantity of fuel is important since space comes at a premium in an aircraft. A fuel with a high volumetric energy content maximised the energy that can be stored in a fixed volume and thus provides the longest flight range. Although the net volumetric energy content or heating value of the GTL kerosene fractions are low (see Table 3), the specified net gravimetrical energy content are greater than the specified 42.8MJ/kg.

The lubricity of the fully synthetic GTL kerosene cut, evaluated with the Ball-on-Cylinder Evaluator (BOCLE) (ASTM D5001 test method), has an unexpected wear scar diameter less than the maximum wear scar diameter that is specified for Jet A1.

Kero-Merox GTL kerosene blend

According to the specific approval of semi-synthetic jet fuel as Jet A-1, its aromatic content must not be less than 8 vol-%. With GTL Fuel containing no aromatics (<0.001 mass-%), the 45 vol-% GTL kerosene cut was blended in a 50/50 ratio with Natref™ crude derived kerosene from Merox™. The properties of the fully synthetic GTL as blending stock (see Table 1) and Kero Merox™ and a blend thereof are also summarised in Table 2.

With a first round calculated aromatic content and density of a 50 vol-% blend of Kero-Merox and a 45 vol-% GTL kerosene fraction, the blend had an aromatic content of 7.55 vol-% and density of 0.780kg/l. The Kero-Merox used for the actual blend had a density of 0.805kg/l and the semi-synthetic blend had a boundary specified density of 0.772kg/l. The aromatic content of the blend was beyond the 8 vol-% limit (see Table 1).

The freezing point, lubricity, viscosity at –20°C and distillation profile of the 50 vol-% Kero-Merox – GTL kerosene blend (see Figure 3) conformed to Jet A1 requirements.
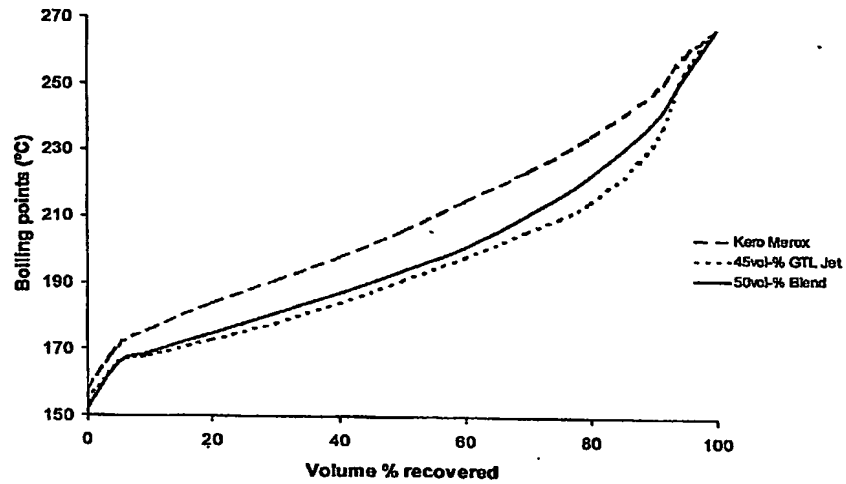
13

Figure 3: *Distillation profiles of Kero Merox, the 45% GTL Jet fraction and a 50% blend thereof*

14

Synthetic kerosene blends with crude derived jet fuel have already been approved with certain limitations. These include synthetic kerosene derived solely from the Fischer-Tropsch process without the inclusion of synthetic aromatic compounds. The light GTL Fuel kerosene with a final boiling point of 270°C conforms to these limitations and also to the freezing point requirement for Jet A1 of −47°C. As a blend, its density and aromatic content will also conform to the minimum requirement of 0.775 kg/l @ 15°C or 0.771kg/l @ 20°C and an 8 vol-% aromatic content.

Exhaust Emission Performance Of the Heavy Cut diesel

The exhaust emissions of a heavy cut of GTL diesel fuel were compared with those of the full boiling range GTL diesel, as well as a European reference diesel fuel. The tests were performed using a late model European passenger car. It was found that the emission performance was not adversely affected when compared to the reference fuel, although unburned hydrocarbons, carbon monoxide, and particulate matter emissions deteriorated when compared with the fuel boiling range GTL diesel. The higher volumetric energy content of the heavy cut GTL diesel resulted in an improvement of 2% in the measured fuel consumption when compared to the full boiling range GTL diesel, although fuel consumption was still approximately 3% less than with the reference fuel.

Test vehicle

Model :	2002 BMW 320d sedan
Test Mass :	1 474 kg
Engine displacement :	1 995 cm^3
Bore / stroke :	84 / 90 mm
Compression ratio :	17 : 1
Power output :	110 kW @ 4000 rev/min
Maximum torque :	330 Nm @ 2000 rev/min
Fuel injection system :-	Bosch common rail
Exhaust aftertreatment :	Dual oxidation catalysts
Emission certification :	EU 3 (2000)

15

Test Fuels

Three fuels were tested for the comparison:

EN590 :   A diesel fuel meeting the European EN 590 specification, and with a sulphur content of < 10 mg/kg

EGTL :   GTL diesel

GTLHC :   A heavy cut of EGTL, comprising of the remainder after a 45% v/v kerosene fraction had been removed by fractionation

Relevant fuel specifications are provided in Table 1 above:

Test Procedure

The emission tests were conducted by Eurotype Test Center in East London, South Africa, and were performed according to European EC/ECE test method, and using the NEDC test cycle. Two pre-conditioning runs were performed in preparation for each test. Three tests were performed with each of the EN590 and EGTL fuels, and two tests were performed with the GTLHC fuel. The fuels were tested sequentially, and the vehicle was warmed up and run at a speed of 120 km/h for a period of 5 minutes after each fuel change.

Results

The results for the ECE R15 urban cycle, the EUDC highway cycle, and the combined ECE R15 + EUDC cycle, are presented in Tables 3, 4, and 5 below.

Table 3 : ECE R15 Urban Cycle Emissions and Fuel Consumption

Fuel		Exhaust Emissions (g/km)					FC (ℓ/100km)
		CO	HC	NO_X	PM	CO_2	
EN590	Avg.	0.419	0.077	0.391	Not	220.4	8.40
	Std Dev	0.078	0.019	0.012		3.611	0.141

16

	COV (%)	18.6	25.2	3.0		1.6	1.7
EGTL	Avg..	0.113	0.031	0.388		212.7	8.89
	Std Dev.	0.011	0.005	0.011		1.246	0.051
	COV (%)	9.4	14.8	2.9		0.06	0.6
GTLH C	Avg.	0.152	0.035	0.371		211.7	8.64
	Std Dev	0.003	0.001	0.000		0.896	0.037
	COV (%)	1.7	3.8	0.1		0.4	0.4

17

Table 4 : EUDC Highway Cycle Emissions and Fuel Consumption

Fuel		Exhaust Emissions (g/km)					FC (ℓ/100km)
		CO	HC	NO_X	PM	CO_2	
EN590	Avg.	0.008	0.003	0.295		127.2	4.84
	Std Dev	0.001	0.000	0.001		1.363	0.052
	COV (%)	15.6	12.4	0.4		1.1	1.1
EGTL	Avg..	0.010	0.003	0.283		123.1	5.14
	Std Dev.	0.004	0.000	0.008		1.071	0.045
	COV (%)	35.3	10.8	2.9		0.9	0.9
GTLHC	Avg.	0.008	0.003	0.279	Not measured	123.2	5.03
	Std Dev	0.000	0.000	0.009		0.097	0.004
	COV (%)	5.2	15.7	3.1		0.1	0.1

Table 5 : Composite ECE + EUDC Cycle Emissions and Fuel Consumption

Fuel		Exhaust Emissions (g/km)					FC (ℓ/100km)
		CO	HC	NO_X	PM	CO_2	
EN590	Avg.	0.159	0.030	0.330	0.025	161.4	6.15
	Std Dev	0.029	0.007	0.004	0.000	2.064	0.080
	COV (%)	18.1	23.9	1.3	1.6	2.2	1.3
EGTL	Avg..	0.048	0.013	0.322	0.202	156.0	6.52
	Std Dev.	0.002	0.002	0.009	0.001	1.118	0.047
	COV (%)	3.3	14.8	2.9	4.4	3.0	0.7
GTLHC	Avg.	0.061	0.015	0.313	0.265	155.8	6.36
	Std Dev	0.000	0.000	0.005	0.000	0.378	0.015
	COV (%)	0.7	1.3	1.7	1.0	1.7	0.2

The results are also presented graphically in Figures 4 to 9.

Discussion of Results

18

Comparison with EN590 Diesel

The differences between the GTLHC and EN590 diesels, expressed as a percentage of the EN590 result, are depicted graphically in Figure 10. It can be seen that both HC and CO emission levels are significantly lower with the GTLHC diesel, and that these differences occur exclusively in the urban (ECE) part of the test cycle, which includes the cold-start. These differences can likely be attributed to the significantly higher cetane number of the GTLHC fuel (74,7 vs 54), which results in shorter ignition delays, and hence the amount of fuel burned in the premixed combustion phase. This results in a reduction in air-fuel mixing inconsistencies, leading to more complete combustion, and hence lower HC and CO emissions. When the oxidation catalyst has reached operating temperature, the HC and CO emission levels become extremely low, regardless of the type of fuel used, as witnessed by the results from the extra-urban or highway (EUDC) part of the test cycle.

NOx and PM emissions with the GTLHC diesel are slightly lower (by 5%), and slightly higher (by 4%), than with the EN590 diesel, respectively. While the difference in NOx emissions is not significant at the 95% confidence level, the difference in PM emissions is.

The difference in NOx emissions can be seen to occur during both the ECE and EUDC cycles. A variety of fuel parameters may contribute in different ways to the difference in NOx emissions. NOx reductions with the GTLHC fuel may result from the higher cetane number (which results in lower heat release rates), and the higher H/C ratio (which results in a lower flame temperature), while the lower density of the GTLHC fuel may result in differences in EGR (Exhaust Gas Recirculation) rates during the test, resulting in higher NOx formation. It is not possible to distinguish between the different mechanisms, and the resultant difference is likely to be a combination of all of these factors.

No differentiation is made between the different phases of the test in the particulate measurement, as the measurement is made over the composite (ECE + EUDC) test cycle. PM emissions with the GTL fuels would normally be expected to be lower than

19

with the EN590 fuel, primarily due to the absence of aromatics. In the case of the GTLHC, however, the small increase in particulates indicates that the removal of the lighter fraction of the GTL diesel negates any such advantage.

CO_2 emissions are 3% lower with the GTLHC fuel, due to its lower carbon content, while volumetric fuel consumption is higher by 3%, due to the lower density of the GTLHC fuel, which results in a lower volumetric energy content.

Comparison with GTL Diesel

A comparison between the GTLHC and EGTL diesels is shown in Figure 11. It can be seen that HC and CO emissions are approximately 10% and 28% higher with the GTLHC fuel, respectively. These differences are likely to be due to the differences in distillation characteristics, with more complete evaporation and mixing occurring with the EGTL, resulting in more complete combustion. While the GTLHC has a higher cetane number than the EGTL fuel, the difference is small and not likely to have a major impact on these emissions.

NOx emissions are 3% lower with the GTLHC fuel, a difference that is not statistically significant. It is notable that PM emissions with the GTLHC fuel are significantly higher (by 31%) than with the EGTL fuel. Of the fuel parameters that generally affect PM emissions, only distillation is significantly different between the two fuels, and is therefore likely to be responsible for the difference in PM emissions. Viscosity, which is also higher with the GTLHC fuel, may also have an effect through its effect on droplet formation during the injection process.

As expected, the difference in CO_2 emissions is negligible, as the fuels have very similar carbon contents. Due to its higher density, fuel consumption with the GTLHC fuel is approximately 2% lower with the GTLHC fuel.

Conclusions

The following may be concluded from the tests performed:

20

- Use of the heavy cut of GTL diesel fuel did not adversely affect the exhaust emissions emissions of the test vehicle, when compared to a European EN590 reference diesel fuel. HC and CO emissions were lower than the EN590 fuel, while NOx and particulate emissions where similar. All regulated emissions were well within the Euro 3 limits for which the test vehicle is certified.

- Removing the lighter 55% of the EGTL diesel fuel results in increases in HC, CO and PM emissions, when compared to the full boiling range EGTL fuel. While HC and CO emissions are still lower than with the EN590 reference fuel, PM emissions were similar to the EN590 fuel, and some 30% higher than the EGTL fuel.

- The increased density of the heavy cut of the GTL fuel results in an improvement in volumetric fuel consumption of 2%, when compared to the EGTL diesel. Fuel consumption is still some 3% higher than with the EN590 diesel fuel, however.

21
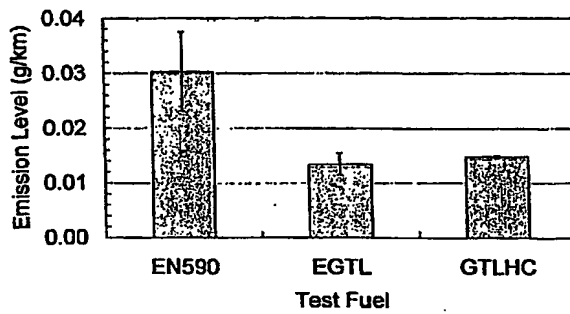
Figure 4 : Composite HC Emissions
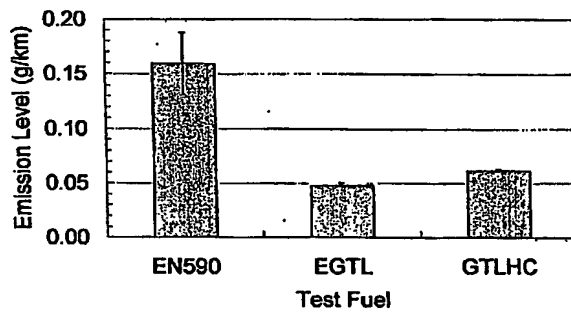
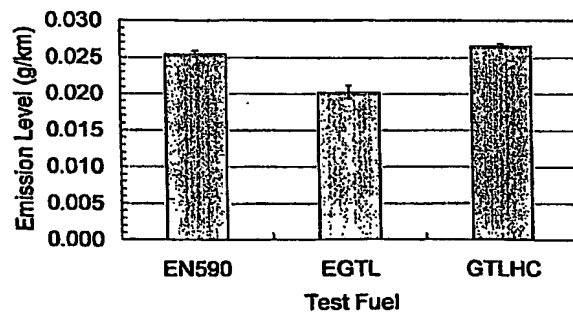Figure 5 : Composite CO Emissions
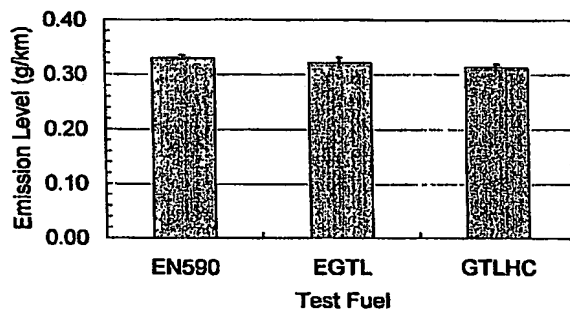
5

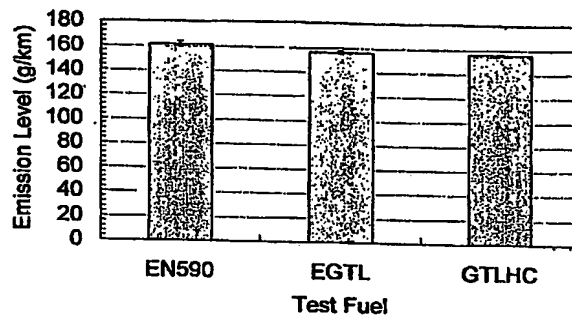Figure 6 : Composite NOx Emissions
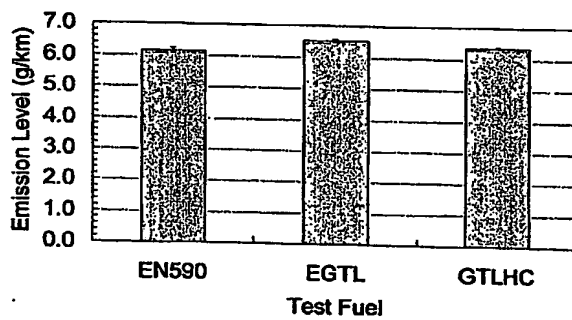

22

Figure 7 : Composite PM Emissions

Figure 8 : Composite CO₂ Emissions
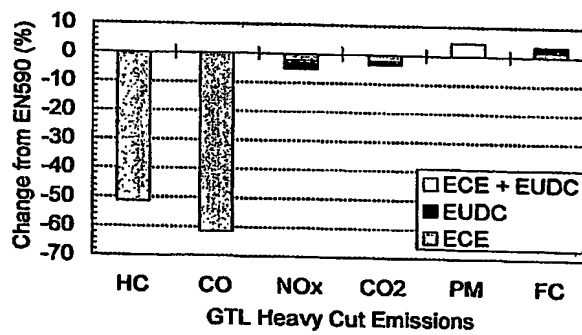

5   Figure 9 : Fuel Consumption
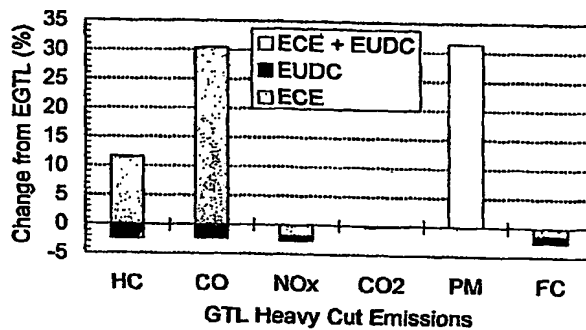

Figure 10 : GTLHC Emissions vs EN590

Figure 11 : GTLHC Emissions vs EGTL

5   THERMAL STABILITY

The thermal oxidation stability of the fully synthetic aviation fuel and semi-synthetic aviation fuel (blends of the light GTL kerosene fractions with KeroMerox were determined according to the jet fuel thermal oxidation tester (JFTOT) ASTM
10   D3241 test method. The visual tube deposite rating for the fully as well as the semi-synthetic aviation fuel were less than 1 with no pressure drop across the filter.

Thermal stability results with the Quartz Crystal Microbalance (QCM) confirmed
15   the JFTOT results with only 2 $\mu g/cm^2$ deposition observed after the 15 hour test at 140°C without the presence of anti-oxidants.

Tests with the JP-8+100 thermal stability improving additive did not improve the stability of the synthetic aviation fuel and blends thereof since the fuel is such a
20   low depositor.

24

Soot Emissions

Gas turbine engine tests results on particulates (soot) of the fully synthetic aviation fuel and blends thereof under idle and cruise conditions were compared with that of JP-8. The fully synthetic GTL light kerosene cut formed 40% less soot under cruise conditions than JP-8 whereas a blend thereof formed 33% less soot under cruise conditions.

Under idle conditions, the GTL kerosene blend stock formed 83% less soot compared to JP-8, whereas blends thereof formed 67% less soot.

25

United States Patent & Trademark Office
Office of Initial Patent Examination

Application papers not suitable for publication

SN __60/462580__   Mail Date __'04/11/03__

- ☐ Non-English Specification
- ☒ Specification contains drawing(s) on page(s) __all__ or table(s) _____
- ☐ Landscape orientation of text   ☐ Specification   ☐ Claims   ☐ Abstract
- ☐ Handwritten   ☐ Specification   ☐ Claims   ☐ Abstract
- ☐ More than one column   ☐ Specification   ☐ Claims   ☐ Abstract
- ☐ Improper line spacing   ☐ Specification   ☐ Claims   ☐ Abstract
- ☐ Claims not on separate page(s)
- ☐ Abstract not on separate page(s)
- ☐ Improper paper size -- Must be either A4 (21 cm x 29.7 cm) or 8-1/2"x 11"
  - ☐ Specification page(s)_____   ☐ Abstract
  - ☐ Drawing page(s)_____   ☐ Claim(s)
- ☐ Improper margins
  - ☐ Specification page(s)_____   ☐ Abstract
  - ☐ Drawing page(s)_____   ☐ Claim(s)
- ☐ Not reproducible   Section
  - Reason   ☐ Specification page(s)_____
  - ☐ Paper too thin   ☐ Drawing page(s)_____
  - ☐ Glossy pages   ☐ Abstract
  - ☐ Non-white background   ☐ Claim(s)
- ☐ Drawing objection(s)
  - ☐ Missing lead lines, drawing(s)_____
  - ☐ Line quality is too light, drawing(s)_____
  - ☐ More than 1 drawing and not numbered correctly
  - ☐ Non-English text, drawing(s)_____
  - ☐ Excessive text, drawing(s)_____
  - ☐ Photographs capable of illustration, drawing(s)_____